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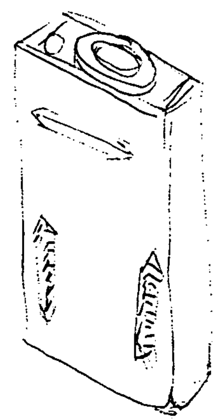

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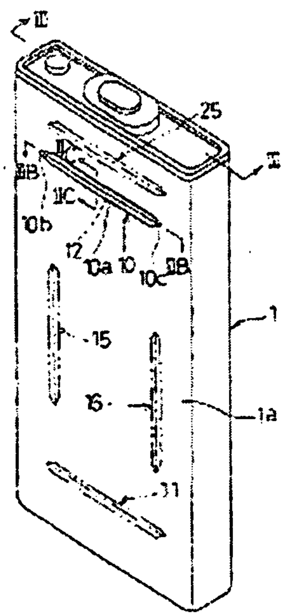
Refer to "Guidance Notes for Codes and Abbreviations" on the first page of each periodically published *PCT Gazette* for 2-letter [country] codes and other abbreviations.

(54) Title of the Invention: Safety Mechanism for Rectangular Battery and Method of Manufacturing the Same



(57) Abstract: A safety mechanism for rectangular battery having a groove (10) cut in the long side face (1a) of a battery case (1) and provided with a thin easy-to-tear part (12) provided between the bottom of the groove (10) and the inner face of the battery case (1) and torn when the inner pressure of the battery case (1) reaches a specified level. When the safety mechanism is manufactured, a cutter (37) rotating at high speed through a high speed rotator (30) is positioned in a relative position of a specified depth cut into the long side face (1a) of the battery case (1) of a completed rectangular battery and then the high speed rotator (30) or the rectangular battery is relatively moved linearly.

SPECIFICATION

Safety Mechanism for Rectangular Battery and Method of Manufacturing the Same

Field of Technology

This invention relates to a safety mechanism that is provided in a rectangular battery in which the generating element is housed in a comparatively flat, rectangular battery case and that, when gas pressure inside has risen to an abnormal level, makes an opening in the battery case so that gas release is effected and the invention also relates to a method for manufacturing said safety mechanism.

Background Technology [Prior Art]

Secondary batteries, which are used as power sources for portable electronic devices, must have high energy density, and, at the same time, must be of a shape for good use efficiency for the purpose of making batteries lighter and smaller. Square lithium secondary batteries for which comparatively flat, rectangular battery cases made of aluminum are used have drawn attention as batteries that satisfy these requirements. It is necessary that these lithium secondary batteries have the capacity to be sealed in a stable state over long periods of time, because a nonaqueous electrolytic solution (an organic solvent electrolytic solution) is housed in the battery case. After the electrode assembly has been housed inside a rectangular battery case having a bottom, a sealing

plate is laser-welded to the opening of the battery case to close the opening.

In secondary batteries with nonaqueous electrolytic solution such as the aforementioned lithium secondary batteries, gas is generated when there is a state of overcharging, a short-circuiting state occurring due to erroneous use, or the nonaqueous electrolytic solution breaks down. When this gas fills the sealed battery case and when, as a result, the internal pressure of the battery rises above a certain level, this results in rupture of the battery case. There is a greater possibility that the aforementioned difficulty will occur in secondary batteries with a nonaqueous electrolytic solution than in other types of batteries. In order to prevent a rupture of the battery case, a safety mechanism is established in advance whereby an opening is formed in a part of the battery case due to the pressure when the internal pressure of the battery case has exceeded a certain level and whereby the gas is discharged to the exterior of the battery case through said opening.

Generally known conventional safety mechanisms for secondary batteries with nonaqueous electrolytic solution are shown in Figure 11A to Figure 11C. The first conventional safety mechanism shown in Figure 11A is constructed by forming the gas extraction pore 3 in an aluminum sealing plate 2 (for example, of 900 μm in thickness) that blocks the opening at the top end of the rectangular battery case 1 having a bottom and by affixing an aluminum thin plate 4 (for example, of 30 μm in thickness) to the bottom face of the sealing plate 2 in a vacuum. When the internal pressure of the battery case 1 has risen above a

specified level, the component 4a that blocks the gas extraction pore 3 in the thin plate 4 is subjected to increased pressure due to the gas pressure so that it breaks, and the internal gas, which passes through the opening that is produced by breaking of the thin plate 4 and through the gas extraction pore 3, is discharged to the exterior of the battery case 1.

The second conventional safety mechanism shown in Figure 11B is constructed by forming the circular in-plane carved groove 7 that is V-shaped in cross-section in one of the long side faces in the rectangular battery case 1 having a bottom and by installing the thin, easily broken part 8 between the thin bottom face of the carved groove 7 and the inside face of the battery case 1. When the internal pressure of the battery case 1 has risen above a certain level, the easily broken component 8, which is of lower strength than the other sites in the long side face 1a, ruptures and an opening is made, with the gas being discharged to the exterior through this opening.

The third conventional safety mechanism shown in Figure 11C is constructed by forming the carved groove 9 having a linear part parallel to the edgeline of the battery case 1 and having V-shaped parts at both ends on the bottom face of the battery case 1. Because the carved groove 9 is formed on the bottom face 1b, which is the part with the smallest area of the battery case 1, when the long side faces 1a and 1c on both sides of the battery case 1 swell outwards accompanying elevation of the internal pressure, the carved groove 9 ruptures due to the fact that the bottom face 1b is deformed inwards and the gas is discharged to the exterior through this opening.

However, the aforementioned first safety mechanism requires punch processing of the gas extraction pore 3 in the comparatively smaller rectangular sealing plate 2, processing to activate the face on one side that becomes the inside face at the time of installation of this sealing plate 2 to the battery case 1 and vacuum suction processing for the purpose of clamping the thin plate 4 by means of a roller and making it into a single unit with the one face that has been activated. For this reason, there is the drawback that manufacturing costs are increased. Moreover, because the gas extraction pore 3 is formed on the end part of the comparatively smaller sealing plate 2, the gas pressure for breaking the component 4a that blocks the gas extraction pore 3 acts only on extremely localized components as seen from the viewpoint of the entire battery case 1. For this reason, there is the problem that it takes time until the component 4a that blocks the gas extraction pore 3 breaks. Therefore, conventionally, an attempt has been made to change the thin plate 4 from the former 30 μm to a thinner 20 μm with the objective of causing the thin plate 4 to break more rapidly at the time the internal pressure of the battery has reached a specified level. However, when the thin plate 4 is made thinner, the new problem occurs that the thin plate 4 is broken due to impact when dropping tests of the battery are performed.

Further, with the aforementioned second safety mechanism, the circular wedge-shaped carved groove 7 is formed by performing press processing using a metal punch on the long side face 1a of a thickness on the order of 300 μm of the battery case 1, with the easily-broken component 8 with a residual thickness

of 80 μm being established. Therefore, work hardening occurs due to heat stress during press processing. Because the degree of change in physical propertiesis not fixed, in short, the extent that the material becomes hard and brittle, the internal pressure of the battery at the time the easily-broken component 8 breaks cannot be set at a fixed level. Moreover, in order to prevent the admixture of dust inside the battery case, the carved groove 7 is formed in a state in which the opening of the battery case 1 is temporarily sealed by the sealing plate. However, at this time, the long side face 1a of comparatively broader area is subjected to stress by the flow of the material when press processing is performed and the sealing plate 2 opens slightly relative to the opening of the battery case 1. For this reason, when the sealing plate 2 is affixed to the battery case 1 by laser welding, a blowhole is formed and this small hole facilitates leakage of the electrolytic solution.

Further, with the aforementioned third safety mechanism, the carved groove 9 is formed in the bottom face 1b, which is of the smallest area, in the battery case 1, for which reason the problem of opening of the sealing plate 2 during press processing that occurs with the aforementioned second safety mechanism does not occur here. However, because the carved groove 9 is formed by press processing, as is the case with the second safety mechanism, the physical properties in the vicinity of the carved groove 9 undergo changes due to work hardening during press processing and there is the problem that the internal pressure of the battery when the safety valve operates is not fixed. Moreover, the carved groove 9 is formed on the bottom face 1b which is the

component of the smallest area in the battery case 1 and which does not readily undergo deformation even when internal pressure rises, for which reason the residual thickness of the carved groove 9 must be made smaller for the purpose of operation at the specified internal pressure of the battery. Because highly precise control of thickness is necessary, there is poor processability of the curved groove 9, and, because the residual thickness of the bottom part of the groove of the carved groove 9 is thin, there is extremely poor tolerance when [the battery is] dropped. Moreover, when a battery pack is constructed by housing multiple batteries as a package in a state in which they are connected in series or in parallel, there is the additional problem that connection by soldering of leads is difficult due to the presence of the carved groove 9 that is formed in the bottom face 1b of the battery case 1.

Accordingly, the object of this invention, which was developed in light of the conventional problems described above, is to provide a safety mechanism for square batteries that, while being of a simple structure, operates precisely and rapidly at the point in time that the internal pressure of the battery has reached a specified level and also to provide a method for easily manufacturing said safety mechanism, with the occurrence of difficulties being prevented.

Disclosure of the Invention

In order to accomplish the aforementioned object, this invention is characterized in that it is a safety mechanism whereby a part of the battery case is opened and gas discharge is effected when the internal gas pressure in a

rectangular battery in which the electrode plate and electrolytic solution are housed in the interior of a rectangular battery case has risen abnormally, in that a cut groove is formed in the long side face of the aforementioned battery case and in that a thin, easily broken component, which is set to a strength at which it will break when the internal pressure of the battery case reaches a specified level, is installed between the groove bottom face of the aforementioned cut groove and the inside face of the aforementioned battery case.

The easily broken component, which is of the residual thickness of the groove bottom part of the cut groove in the safety mechanism of the rectangular battery, is formed on the long side face, which is a region of broad area of the battery case and which undergoes great deformation accompanying elevation of the internal pressure of the battery. Therefore, the easily broken component reliably and rapidly undergoes breakage at the point in time that the internal pressure of the battery has reached the operating pressure of the safety mechanism. Further, because the cut groove is formed by cutting processing by means of a cutter, there is the difference from press processing in that work hardening attributable to heat stress does not occur, for which reason changes in physical properties in the vicinity of the cut groove do not occur. Consequently, the operating pressure of the safety mechanism, which is set by the thickness of the easily broken component, can be controlled with a high degree of precision and the safety of the rectangular battery can be increased.

In addition, the method of manufacture of the safety mechanism for square batteries of this invention is characterized in that has a process in which the

rectangular battery is manufactured by housing the electrode plates and electrolytic solution inside a rectangular battery case having a bottom, after which the opening of the aforementioned battery case is sealed, and a process in which a cutter that is installed in a high-speed rotator and that rotates at high speed is brought into contact with and cuts into the long side face in the aforementioned battery case in the aforementioned rectangular battery, after which it is positioned in the relative position of the depth at which the easily broken component of a specified thickness is installed, the aforementioned high speed rotator or the aforementioned rectangular battery is subjected to relative movement in a linear direction, and a cut groove is formed on the aforementioned long side face by repeated rotation of the aforementioned cutter.

Because a cut groove is formed on the long side face of the completed rectangular battery in the method of manufacture of the safety mechanisms of square batteries, the dirt and dust that are generated during the processing of this cut groove are not admixed inside the battery case. Further, because the cut groove is formed by cutting processing several times by a cutter that rotates at high speed, work hardening that is attributable to hot pressing does not occur, the operating pressure of the safety mechanism can be controlled with high precision and the problem does not occur of the sealing plate being open relative to the opening of the battery case due to stress attributable to the flow of materials during processing. Further, because the cutter groove is processed while the high speed rotator to which the cutter is attached and the rectangular battery are being subjected to relative movement linearly, a cut groove that

extends to the outside face of the battery case and that is of a cross-sectional shape having a groove bottom of two bends can be formed precisely while bending from the two ends of the linear groove bottom that extends linearly at the same depth.

Simple Description of the Figures

Figure 1 is an oblique view that shows a rectangular battery that is provided with a safety mechanism of the first embodiment of this invention.

Figure 2A is a frontal view of the formed component of the cut groove of Figure 1, Figure 2B is cross-sectional view along the line IIB-IIB in Figure 1 and Figure 2C is a cross-sectional view along the line IIC-IIC of Figure 1.

Figure 3 is a cross-sectional view along the line III-III of Figure 1.

Figure 4A through Figure 4C are cut-away right lateral views that show the sequence of the process up to breakage of the easily broken part in a rectangular battery equipped with a safety valve of the second embodiment of this invention as a result of the elevation of the internal pressureof the battery.

Figure 5A and Figure 5B are a frontal view and a right lateral view that show the cutting device that is used in the method of manufacture of the safety mechanism of a rectangular battery of the first embodiment of this invention.

Figure 6 is a cut-away plane view that shows the state of processing the cut groove by the aforementioned cutting device.

Figure 7 is a transverse view of the essential component that shows the safety mechanism of a rectangular battery of the third embodiment of this

invention.

Figure 8 is a transverse view of the essential component that shows the safety mechanism of a rectangular battery of the fourth embodiment of this invention.

Figure 9 is a transverse view of the essential component that shows the safety mechanism of a rectangular battery of the fifth embodiment of this invention.

Figure 10 is a transverse view of the essential component that shows the safety mechanism of a rectangular battery of the fifth embodiment of this invention.

Figure 11A through Figure 12C are, respectively, a cross-sectional view that shows the first safety mechanism, a cross-sectional view that shows the second safety mechanism and an oblique view that shows the third safety mechanism of conventional batteries of the prior art.

Preferred embodiment

We shall now describe a preferred embodiment of this invention by reference to the figures. Figure 1 is an oblique view that shows a rectangular battery that is provided with a safety mechanism of the first embodiment of this invention. Figure 2A is a frontal view of the formed component of the cut groove of Figure 1, Figure 2B is cross-sectional view along the line IIB-IIB in Figure 1 and Figure 2C is a cross-sectional view along the line IIC-IIC of Figure 1. As shown in Figure 1, the linear, single cut groove 10 is formed on one of the long

side faces 1a of the rectangular battery case 1 on the long side face 1a and parallel to its lower edge. As shown in figure 2B, the thin easily broken component 12 is set between the groove bottom of the cut groove 10 and the inside face of the battery case 1 so that it breaks when internal pressure in the battery case 1 has risen to a specified level. In this embodiment, the easily broken component 12 is formed at a site close to the upper edge of the long side face 1a of the battery case 1, specifically, at a site on the upper edge side among 3 sites that divide the long side face 1a into three equal parts in the vertical direction.

As shown in Figure 2C, the cross section of the aforementioned cut groove 10 in the width direction that is perpendicular to the lengthwise direction is essentially V-shaped. Further, as shown in Figure 2B, the cross section of the cut groove 10 in the lengthwise direction is of a shape in which the linear groove bottom 10a, which extends linearly at the same depth and which forms the easily broken part 12 due to the residual thickness of the groove bottom, adjoins the two curved groove bottom parts 10b and 10c each of which are curved from the two ends of the linear groove bottom 10a and that extend to the outside face of the long side face of the battery case 1.

Figure 3 is a cross-sectional view along the line III-III of Figure 1. This figure also shows an example of a lithium ion secondary battery, which is a type of rectangular battery. Next, we shall present a brief description of the structure of this lithium ion secondary battery. The lithium ion secondary battery must have stable sealing properties over long periods because a nonaqueous

electrolytic solution (not shown in the figure) is housed inside the battery case 1. Therefore, after the electrode assembly 13 has been housed in the rectangular battery case 1 having a bottom, the sealing plate 17 is laser-welded to the opening 14 of the battery case 1 to block the opening 14. Following that, the electrolytic solution is poured into the battery case 1 in a specified quantity through the solution pouring hole 18 that is formed in the sealing plate 17, and, finally, the solution pouring hole 18 is sealed by the sealing component 19.

The battery case 1 is a metal plate such as an aluminum plate, a nickel-plated steel plate, a clad steel plate or an SUS steel plate. The electrode assembly 13 is inserted into the interior of this battery case 1. The bottom end of the electrode assembly 13 is electrically insulated and partitioned off from the inside bottom face of the battery case 1 by the insulating plate 21 and the top end of the electrode assembly 13 is electrically insulated by the insulating plate 22.

The anode terminal 27 is installed in the sealing plate 17 by the installation hole 23 at its center through the agency of the insulating gasket 24. The anode lead 28, which leads out from the electrode assembly 13 through the insertion hole 22a in the insulating plate 22, is connected by welding to the bottom face of the anode terminal 27. The cathode lead 20, which leads out from the electrode assembly 13 through the insertion hole 22b of the insulating plate 22, is connected by welding to the sealing plate 17. At the time of battery assembly, the sealing plate 17 is inserted into the opening 14 of the battery case 1 and its periphery is affixed by laser welding to the inside circumferential face of the battery case 1, after which a specified quantity of electrolytic solution is poured in

through the solution pouring hole 18 and the solution pouring hole 18 is sealed by the sealing plug component 19. Because the sealing plate 17 has only the solution pouring hole 18 and the installation hole 23 and is not equipped with the gas discharge pore 3 and the thin plate 4 such as the sealing plate with which the conventional first safety mechanism is provided, it can be manufactured inexpensively.

Next, we shall describe the action of the aforementioned safety mechanism. The internal pressure of the battery, which is the operating pressure for breaking the easily broken component 12, is set by the thickness of the easily broken component 12. When the rectangular battery goes into an overcharge state during use or into a short-circuit state due to incorrect use, the gas that is produced fills the interior of the battery case 1, the internal pressure of the battery rises and the battery case swells outwardly accompanying this.

At this time, the entire central part of the long side face 1a of the battery case 1 is swollen outwards. However, the region close to the aforementioned cut groove 10 in the long side face 1a is in the boundary region between the swollen-out site and the site that is not swollen out and is a region in which the greatest stress changes occur. In the aforementioned cut groove 10, the inclined region at the top edge in the width direction that is perpendicular to the lengthwise direction is essentially not swollen out when the internal pressure of the battery is elevated, whereas the inclined region at the center in the aforementioned width direction is greatly swollen out. In short, the cut groove 10 is deformed in a state in which the groove opening is opened wide accompanying

elevation of the internal pressure of the battery and goes into a state in which the easily broken component 12, which is installed in the groove bottom region of the cut groove 10, is easily broken. When the internal pressure of the battery has risen to the specified operating pressure, the easily broken component 12 is subjected to shearing force and breaks and the gas inside the battery case 1 is released to the exterior through the opening that is produced as a result of this.

The easily broken component 12 in this safety mechanism is formed in a wide area region of the battery case 1 and the long side face 1a undergoes great deformation due to the elevation of the internal pressure of the battery. Therefore, when the internal pressure of the battery has reached a specified operating pressure, the easily broken component is reliably and rapidly broken. Consequently, because the easily broken component 12 can be set to a thickness that is greater than that of conventional safety mechanisms, the tolerance when dropped is increased. Moreover, because control of precision is facilitated, the processability of the cut groove 10 is increased.

Further, the cut groove 10 is formed by cutting processing with a cutter as will be described subsequently. Therefore, it differs from the conventional carved grooves 7 and 9 in that work hardening attributable to heat stress during press processing does not occur. Because the physical properties in the vicinity of the cut groove 10 are not changed, setting of the operating pressure of the safety mechanism based on the thickness of the easily broken component 12 is performed precisely, and, therefore, the safety of the rectangular battery is extremely high.

Moreover, in spite of the fact that the cut groove 10 is formed on the long side face 1a which is of a comparatively wide area, it is formed by cutting processing in which the thickness of the material is not compressed, for which reason stress deformation attributable to the flow of material during processing does not occur. Consequently, even when the cut groove 10 is formed in a state in which the opening 14 of the battery case 1 is temporarily sealed by the sealing plate 17, the problem does not occur that the sealing plate 17 is opened relative to the opening 14 of the sealing plate 17 and leakage of electrolytic solution is prevented. In addition, because this safety mechanism is formed only by the single cut groove 10, there are fewer processes than with the conventional safety mechanism shown in Figure 11A in which the thin plate 4 is affixed to the bottom face of the sealing plate 2, which has the gas discharge pore 3, so that the safety mechanism of this invention can be manufactured inexpensively.

Further, the cut groove 10 is formed of the linear groove bottom 10a, which extends linearly at the same depth and that forms the easily broken component 12 in the groove bottom region, and of the two curved groove bottom components 10b and 10c, which extend to the outside face of the battery case 1 while respectively bending from the two ends of the linear groove bottom component 10a, which components are adjacent. For this reason, when the internal pressure of the battery has reached a specified level, the easily broken component 12, which is of the residual thickness of the linear groove bottom part 10a in the cut groove 10, is reliably broken. By contrast, as shown by the two broken lines in Figure 2B, when the cut groove 60 of which the cross section in

the lengthwise direction is rectangular has been established, there is the possibility that the angular areas 60a and 60b at the two ends of the groove bottom will be broken first. There is the possibility that the difficulty will occur that the easily broken component 12 will break before the internal pressure of the battery reaches the set operating pressure.

The safety mechanism based on the cut groove 10 of the shape described above has the following advantages. Specifically, because the cut groove 10 is essentially V-shaped in cross section in the width direction that isperpendicular to the lengthwise direction, the easily broken component 12 is set in a site between the essentially linear groove bottom part of the cut groove 10 and the inside face of the battery case 1 and the setting of the operating pressure of the safety mechanism based on the thickness of the easily broken component 12 is facilitated. By contrast, when a groove that is essentially U-shaped in cross section is formed by press processing, there are the drawbacks that the corners of both ends of the groove bottom face in the width direction become sites that are easily broken and that the operating pressure of the safety mechanism is not fixed. In addition, because the cut groove 10 is of a shape in which the two ends in the lengthwise direction are of a smaller width than the other regions, the easily broken component 12 that is established in the groove bottom component of the cut groove 10 is specifically placed in the center part of the cut groove 10 in the lengthwise direction.

In the aforementioned embodiment, we described an example of the case in which a safety mechanism is constructed by the single cut groove 10 that is

established in a site close to the top edge in the long-side face 1a of the battery case 1. The same effect as described above is obtained even when, as shown by the two broken lines in Figure 1, the safety mechanism is constructed of any one of the following single cut grooves: 11, which is established parallel to the top and bottom edges in a site close to the bottom edge in the long side face 1a; single cut groove 15, which is established parallel to both side edges in a site close to the left side edge in the long side face 1a; or the single cut groove 16 that is established parallel to the two side edges in a site close to the right side edge in the long side face 1a.

Specifically, the sites at which the aforementioned cut grooves 11, 15 and 16 in the long side face 1a are established, like the site at which the cut groove 10 is formed, are at the boundary region between the swollen sites and the sites at which there is essentially no swelling out and each represents one of the sites at which the greatest stress changes occur. However, in order to obtain the effects described above, all of the cut grooves 11, 15 and 16 are made with the same shape as the cut groove 10. It goes without saying that it is necessary that the cut groove 11 is in a site that is included near the bottom edge of the three parts into which the long side face 1a is divided in the vertical direction, that the cut groove 15 is formed in a site included to the left side edge of the three parts into which the long side face 1a is divided in the vertical direction and that the cut groove 16 is formed in a site toward the right side edge of the three parts into which the long side face 1a is divided in the vertical direction.

Next, we shall describe the safety mechanism pertaining to the second

embodiment. As shown in Figure 1, it is constructed of the cut groove 10, which is similar to that of which the safety mechanism of the first embodiment is constructed, and of the cut groove 25, which is formed parallel to the cut groove 10, between the cut groove 10 and the top edge of the long-side face 1a. In this safety mechanism, as in the first embodiment, the easily broken component 12 is established between the groove bottom part of the cut groove 10 and the inside face of the battery case 1. The cut groove 25 has essentially the same shape as the cut groove 10. The residual thickness between the groove bottom face and the inside face of the battery case 1is not established as the easily broken component. Specifically, the cut groove 25 is established for the purpose of facilitating the breaking of the easily broken component of the cut groove 10.

Figure 4A through Figure 4C are cut-away right lateral views that show the sequence of the process up to breakage of the easily broken part in a rectangular battery equipped with a safety valve of the second embodiment of this invention as a result of the elevation of battery internal pressure. In all cases, they are cut along the position of line IIC-IIC in Figure 1. We shall now explain the action of the safety mechanism of this embodiment by reference to Figure 4A through Figure 4C. Figure 4A is a cross-sectional view that shows the shape of the two cut grooves 10 and 25 in a state in which the internal pressure of the battery is in the ordinary state. The operating pressure at which easily broken component 12 is broken is set by the thickness of the easily broken component 12. When the rectangular battery goes into an overcharge state during use or when it goes into a short-circuit state due to incorrect use, the gas that is generated fills the battery

case 1 and the internal pressure of the battery rises, with the battery case swelling outwards accompanying this gas generation, as shown in Figure 4B.

At this time, as shown in Figure 4B, the cut groove 25 that is formed at a site that is closer to the top edge than the cut groove 10 in the long side face 1a, that is, at a site of less deformation due to the internal pressure of the battery, is deformed so that the groove tends to collapse when the internal pressure of the battery increases. Therefore, a part of the cut groove 25 that is in the long side face 1a is in a state in which it is bent inwards. The cut groove 10, which is formed in the site of the long side face 12a in which there is the greatest deformation due to the internal pressure of the battery, is deformed so that the groove opening is expanded by the inward bending of the long side face 1a due to the deformation of the cut groove 25 as described above, so that a state in which breaking is facilitated is achieved. When the internal pressure of the battery has risen to a specified operating pressure, the easily broken component 12, as shown in Figure 4C, is broken and an opening is produced and the gas inside the battery case 1 is discharged to the outside through this opening.

With this safety mechanism, in addition to the various effects that have been described in the first embodiment, the cut groove 25, which is formed parallel and close to the site of the cut groove 10 equipped with the easily broken component 12, assists in putting the easily broken component 12 into a state in which it is easily broken while the groove opening of the cut groove 10 is being expanded to a large angle by the deformation itself. Consequently, the thickness d of the easily broken component 12 that is used for setting the operating

pressure can be set to a greater thickness than when only the cut groove 10 is used as in the first embodiment. Precise control of thickness is further facilitated and processability of the cut grooves 10 and 25 as well as thetolerance when the easily broken component 12 is dropped are both improved. For example, when a single cut groove is formed in the bottom face 1b of the battery case 1, it is necessary to adjust the thickness of the easily broken component that is broken to 1 μm for a pressure of 1 atmosphere. By contrast, when the pair of cut grooves 10 and 25 are formed in a placement adjacent to the long side face 1a, the thickness of the easily broken component 12 that breaks at a pressure of 1 atmosphere becomes 10 μm. Precise control of the thickness of the easily broken component 12 is facilitated by adjusting this thickness to a higher value.

In the second embodiment, we described an example of the case in which the safety mechanism is constructed by the pair of cut grooves 10 and 25 that are established in sites close to the top edge of the long side face 1a. An effect similar to that of the second embodiment as described above can be obtained when the safety mechanism is installed based on the cut groove 15 of Figure 1 and a cut groove that is established between the cut groove 15 and the left side edge of the long side face 1a and the cut groove 16 of Figure 1 and a cut groove that is established between the cut groove 16 and the right side edge of the long side face 1a.

Next, we shall describe the method of manufacture of the safety mechanism of the rectangular battery of this invention for manufacturing the

safety mechanism of the aforementioned second embodiment. Figure 5a is a frontal view that shows the cutting device 29 that is used in the aforementioned method of manufacture and Figure 5B is a right lateral view of it. In this cutting device 29, two pairs, or a total of four identical cutters 37 are installed in a high speed cutter 30 in which two levels of installation blocks 32 and 33 are affixed by the attachment screw 34 to the bottom part of the rotation shaft 31. Each cutter 37 is formed using a material of high hardness, for example, diamond, and the balancers 38 of a specified weight are installed on each of them. Each pair of cutters 37 cuts and processes each cut groove 10 and 25 in the aforementioned safety mechanism and is installed in a position that is formed on the same rotation locus of the high speed rotator 30. The high speed rotator 30, for example, causes the 100-mm cutter 37 to rotate at a high rotational speed of greater than 3000 rpm.

Figure 6 is a cut-away plane view that shows the state of simultaneous processing of the two cut grooves by the aforementioned cutting device 29. After the opening 14 of the battery case 1 has been sealed by the sealing plate 17 and a rectangular battery as shown in Figure 3 has been made, the cut grooves 10 and 25 are processed for the long side face 1a of the battery case 1 of the completed rectangular battery. By this means, the input of admixtures of dirt and dust into the battery case 1 is prevented during the processing of the cut grooves 10 and 25.

At the time of processing of the cut grooves 10 and 25, the cutter 37, during high speed rotation by the high speed rotator 30, is placed in a position

relative to the long side face 1a of the battery case 1 so that it cuts into the depth at which the easily broken component 12 of the specified thickness d is formed. Following that, by causing the high speed rotator 30 to move linearly in the direction parallel to the top and bottom edges of the battery case 1 as shown by the arrows, the two cut grooves 10 and 25 are formed simultaneously in the long side face 1a by multiple rotations of the pair of cutters 37. Alternatively, the high speed rotator 30 may be caused to undergo high speed rotation in a fixed position and the battery case 1 may be moved linearly relative to the high speed rotator 30.

As described above, the cut grooves 10 and 25 are formed as if the long side face 1a is being planed by a carpenter's planer as a result of repeated processing by cutting with the cutters 37 that are rotating at high speed. For this reason, the occurrence of work hardening attributable to heat stress at the sites of formation of the cut grooves 10 and 25 in the long side face 1a is prevented, the easily broken component 12 that is formed in the region of residual thickness of the cut groove 10 can be processed, while precise control of the thickness d is effected precisely in micron units and the difficulty does not occur that the sealing plate 17 is opened relative to the opening 14 of the battery case 1 by the stress attributable to the flow of materials during processing. Further, the cut grooves 10 and 25 are processed by causing the high speed rotator 30, on which the cutter 37 is installed, to move linearly along the long side face 1a. Therefore, the cut groove 10, as shown in Figure 2A, and the linear groove bottom 10a that extends in a straight line at the same depth, are bent from their two ends and are

formed precisely in a cross-sectional shape having the two curved groove bottom parts 10b and 10c that extend to the outside face of the battery case 1. The cut groove 25 is formed in the same cross-sectional shape as the cut groove 10.

The safety mechanism based on the single cut groove 10 (or any one of the other cut grooves 11, 15 and 16) of the first embodiment can be manufactured by the same processes as in the method of manufacture in the aforementioned embodiments using the cutter device 29 of Figure 5A, Figure 5B and Figure 6 in a mode in which any one of the two pairs of cutters 37 are eliminated from the two pairs of identical cutters 37. The same effect as described for the method of manufacture in the embodiments described above is obtained.

In the method of manufacture in the embodiment described above, after the opening 14 of the battery case 1 has been sealed by the sealing plate 17 and the rectangular battery has been manufactured, the single cut groove 10 or the pair of cut grooves 10 and 25 are processed for the long side face 1a of the battery case 1 of the completed rectangular battery. However, the single cut groove 10 or the pair of cut grooves 10 and 25 may also be formed in advance in the long side face 1a of the battery case 1 using the aforementioned cutter device 29 as a unit. In this case, when a defect has occurred in the cut grooves 10 and 25, the battery case 1 which is the defective product can be excluded and only battery cases 1 that are good products can be supplied to the process of battery manufacture. Therefore, there is the advantage that yields of batteries are improved. Further, what is discarded as a defective product is the battery

case and manufacturing costs are decreased in comparison to the case in which the entire rectangular battery is defective and must be discarded.

Figure 7 and Figure 8 are cross sections of the essential components showing the safety mechanisms of the rectangular batteries of the third and fourth embodiments. The cut groove 39, which constitutes the safety mechanism of the third embodiment, as shown in Figure 7, is of a shape in cross section in the lengthwise direction like that of the cut groove 10 of the first embodiment such that the linear groove bottom component 39a that extends linearly at the same depth adjoins the two curved groove bottom components 39b and 39c that extend to the outside face of the battery case 1 while curving from the two ends of the linear groove bottom component 30a and such that the deepest groove bottom component 39d in which the groove bottom is deepest is established. The easily broken component 12 is the residual thickness between the groove bottom face of the deepest groove bottom component 39d and the inside face of the battery case 1.

With this safety mechanism based on the cut groove 39, the same effect as with the safety mechanism based on the cut groove 10 of the first embodiment can be obtained, and, in addition, setting the operating pressure for the purpose of specifying and establishing the easily broken component 12 in a region opposite the deepest part 39d of the groove bottom, which is a small site in the cut groove 30, is further facilitated and can be performed precisely. Further, because the breaking site is a specified small region, the safety of the battery is greatly increased when this safety mechanism operates.

The cut groove 40, which constitutes the safety mechanism of the fourth embodiment, as shown in Figure 8, is in a shape in which, in cross section in the lengthwise direction, the discontinuous groove bottom component 40a, of which the groove bottom depth changes discontinuously, is adjacent to the two curved groove bottom components 40b and 40c that extend to the outside face of the battery case 1 while bending from the two ends of the discontinuous groove bottom component 40a and in which the deepest groove bottom component 40d, where the groove bottom is deepest, is established in the center part of the discontinuous groove bottom component 40a. The easily broken component 12 is the residual thickness between the groove bottom face of the deepest bottom groove part 40d and the inside face of the battery case 1.

The safety mechanism based on the cut groove 40 provides an effect like that of the safety mechanism based on the aforementioned cut groove 39, and, in addition, because the multiple rib-shaped parts 40e through 40h of the discontinuous groove bottom component 49a that protrude into the interior from the groove bottom face bring about an improvement in tolerance to dropping for the battery. Therefore, the difficulty that the easily broken component 12 is easily broken by impact when a device in which the battery is installed is dropped is prevented.

When the long side face 1a of the battery case 1 is cut by the cutters 37, which are installed on the high speed rotator 30 as shown in Figure 6 and which rotates at high speed, the high speed rotator 30 is caused to move linearly along the rectangular battery, and, as shown by the two broken line arrows in the same

figure, the aforementioned cut grooves 39 and 40 are processed precisely in specified shapes as a result of the fact that the cutters 37 are displaced at a specified timing and a specified distance by NC control in a direction that is adjusted relative to the rectangular battery.

Figure 9 is a cross section of the essential component showing the safety mechanism of the fifth embodiment of this invention. In this figure, the same symbols are used for components that are the same or similar to those in Figure 2 and an explanation of them is omitted. In this embodiment, the coating protective film 41 is formed by applying a fluorine resin or a polyolefin resin in the cut groove 10, which is similar to that in the first embodiment, so that it is completely filled. In general, the battery case 1 is protected by an oxide film that is formed on its surface. However, the oxide film is also removed when the cut groove 10a in the long-side face 1a of the battery case 1 is subjected to cutting processing. For this reason, the cut groove 10 is easily corroded by electrolytic solution and salt solution that leak out through the solution pouring hole 18 shown in Figure 3 when the electrolytic solution is poured in. This problem is solved by the coating protective film 41 that is formed in this embodiment. In this embodiment, we have described the case in which the coating protective film 41 is formed in the cut groove 10 that is formed in the first embodiment. However, it goes without saying that a similar coating protective film can be formed in the various cut grooves 11, 15, 16, 25, 39 and 40 that are indicated in the other embodiments.

Figure 10 is an oblique view that shows a rectangular battery equipped

with the safety mechanism of the sixth embodiment of this invention. In this embodiment, the single arc-shaped cut groove 42 is formed in one of the long side faces 1a of the rectangular battery case 1. The site of formation of this cut groove 42, as in the first embodiment, is a site on the top edge side when the long side face 1a is divided into three equal parts in the vertical direction. This cut groove 42, like the cut groove 10 of the first embodiment, is made so that the cross section in the width direction that intersects the lengthwise direction is essentially V-shaped. In addition, the cross section the lengthwise direction is shaped so that the linear groove bottom component 42a, which extends linearly at the same depth, and the two curved groove bottom components 42b and 42c, which extend to the outside face of the long side face 1a of the battery case 1 while curving from the two ends of the linear groove bottom component 42a, are adjacent to each other. The thin easily broken component 48 that has been adjusted to a thickness such that it breaks when the internal pressure of the battery case 1 has risen to a specified level is installed between the groove bottom of the linear groove bottom component 42a and the inside face of the battery case 1.

The safety mechanism based on the cut groove 42 has various effects similar to those of the safety mechanism based on the cut groove 10 of the first embodiment. In addition, at the time of processing the cut groove 42, a rotary cutting and processing machine is used and a rotary cutter is rotated on the surface of the battery case 1 parallel to the long side face 1a, with the cutting groove 42 being continuously processed. For this reason, this safety mechanism

greatly improves productivity when it is put to practical use.

In the embodiment described above, we described an example of the case in which the safety mechanism was constructed by a single cut groove 42 that was established in a site close to the top edge in the long side face 1a of the battery case 1. However, as shown by the dotted broken lines in Figure 10, various similar effects can be obtained also when the safety mechanism is constructed by any one of the following: the single arc-shaped cut groove 43 that is installed in a site close to the lower edge in the long side face 1a, the single arc-shaped cut groove 44 that is installed in a site close to the left side edge in the long side face 1a, and the single arc-shaped cut groove 47 that is installed in a site close to the right side edge in the long side face 1a.

The Possibility of Industrial Use

As described above, by means of the safety mechanism for rectangular batteries of this invention, the easily broken component, which is the residual thickness of the groove bottom component of the cut grove, is formed on the long side face, which is a wide-area region of the battery case and which undergoes great deformation accompanying elevation of the internal pressure of the battery with the result that the easily broken component is reliably and rapidly broken at the time the internal pressure of the battery has reached a specified operating pressure. Further, because the cut groove is formed by cutting processing, work hardening attributable to heat stress during processing does not occur, for which reason the physical properties in the vicinity of the cut groove are not changed.

Consequently, the operating pressure of the safety mechanism which is set by the thickness of the easily broken component can be controlled with high precision.

Further, by means of the method manufacture of safety mechanisms for rectangular batteries of this invention, the cut groove is formed on the long side face of the completed rectangular battery. Therefore, dust and dirt that are produced during processing of the cut groove are not admixed in the battery case. Because the cut groove is formed by cutting processing several times with a cutter that rotates at high speed, occurrence of work hardening attributable to heat stress during processing does not occur and the operating pressure of the safety mechanism which is set by the thickness of the easily broken component can be controlled with high precision.

Claims

1. A safety mechanism for rectangular batteries characterized in that is a safety mechanism whereby a part of the battery case is opened and gas is discharged when there is an abnormal elevation of the gas pressure in the interior of a rectangular battery in which an electrode assembly (13) and an electrolytic solution are housed inside a rectangular battery case (1),

in that a cut groove (10) is formed in the long side face (1a) of the aforementioned battery case and

in that a thin easily broken component (12) that is adjusted to a thickness at which it breaks when the internal pressure of the aforementioned battery case rises to a specified level is installed between the groove bottom face (10a) of the aforementioned cut groove and the inside face of the aforementioned battery case.

2. The safety mechanism for rectangular batteries as described in claim 1 in which the cut groove (10, 11, 15, 16) is formed in the long side face (1a) in any position parallel to the bottom and top edges and parallel to the left and right side edges of the battery case (1).

3. The safety mechanism for rectangular batteries as described in claim 2 in which the cut groove (10, 11, 15, 16) is formed at a site close to the top edge or bottom edge of the long side face (1a) of the battery case (1) which is divided into three equal parts in the vertical direction and at any site that is close to the left side edge or the right side edge which is divided into three equal parts in the vertical direction.

4. The safety mechanism for rectangular batteries as described in claim 1

in which multiple cut grooves (10, 25) are formed in the long side face (1a) in positions so that they are parallel and adjacent to each other.

5. The safety mechanism for rectangular batteries as described in claim 1 in which the cut groove (10) of which the cross-sectional shape in the width direction that intersects the lengthwise direction is essentially V-shaped.

6. The safety mechanism for rectangular batteries as described in claim 1 in which the cut groove (10) is of a shape such that the two ends in the lengthwise direction are smaller in width in the direction perpendicular to the aforementioned lengthwise direction in comparison to the other parts.

7. The safety mechanism for rectangular batteries as described in claim 1 in which the cross section in the lengthwise direction of the cut grooves (10, 39) is of a shape such that the linear groove bottom components (10a, 39a) that extend linearly at the same depth and that form the easily broken component (12) in the groove bottom component are adjacent to the two curved groove bottom components (10b, 10c, 39b, 39c) that extend to the outside face of the battery case (1) while curving from the two ends of the linear groove bottom component.

8. The safety mechanism for rectangular batteries as described in claim 1 in which the cross section in the lengthwise direction of the cut groove (40) is of a shape in which the discontinuous groove bottom (40a) of which the groove bottom depth changes discontinuously is adjacent to the two curved groove bottom components (40b, 40c) that extend to the outside face of the battery case (1) while curving from the two ends of the discontinuous groove bottom component.

9. The safety mechanism for rectangular batteries as described in claim 7 or 8 in which the deepest groove bottom parts (39, 40) where the groove bottoms are the deepest of the cut grooves (39, 40) are formed in specified sites and in which the easily broken component (12) is formed between the groove bottom face of the deepest groove bottom part and the inside face of the battery case (1).

10. The safety mechanism for rectangular batteries as described in claim 1 in which the cut groove (10) is filled and completely covered with a protective coating film (41) obtained by applying a fluorine resin or a polyolefin resin.

11. The safety mechanism for rectangular batteries as described in claim 1 in which the cut groove (42) is arc-shaped and in which its cross section in the lengthwise direction is of a shape such that the linear groove bottom part (42a) that extends linearly at the same depth and that forms the easily broken component (48) in the groove bottom component is adjacent to the two curve groove bottom parts (42b, 42c) that extend to the outside face of the battery case (1) while curving from the two ends of the linear groove bottom component.

12. The safety mechanism for rectangular batteries as described in claim 11 in which the cut grooves (42, 43, 44, 47) are formed in the long side face (1a) in a placement that is either parallel to the top and bottom edges or parallel to the left and right side edges of the battery case (1).

13. A rectangular lithium secondary battery in which the safety mechanism described in claim 1 is installed in the long side face (1a) of the battery case (1).

14. A method for the manufacture of a safety mechanism for

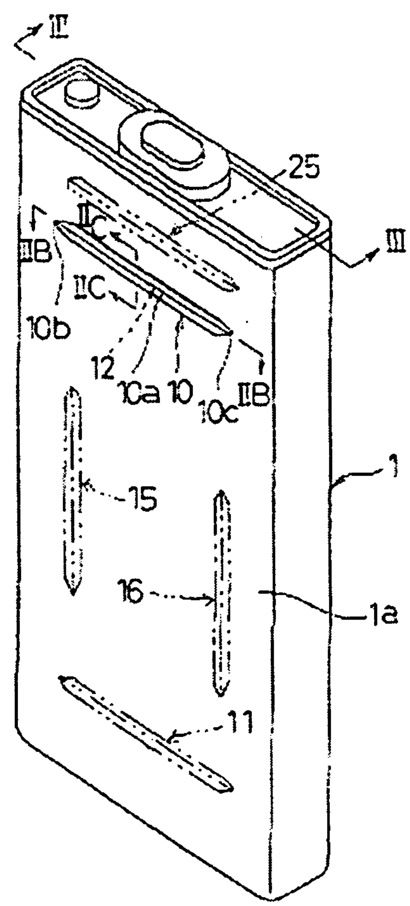
rectangularbatteries characterized in that it has a process in which the rectangular battery is manufactured by housing the electrode plates(13) and electrolytic solution inside a rectangular battery case (1) having a bottom, after which the opening (14) of the aforementioned battery case is sealed, and a process in which a cutter (37) that is installed in a high-speed rotator (30) and that rotates at high speed is brought into contact with the long side face (1a) and cuts into this face in the aforementioned battery case in the aforementioned rectangular battery, after which it is positioned in the relative position of the depth at which the easily broken component (12) of a specified thickness is installed, the aforementioned high speed rotator or the aforementioned rectangular battery is subjected to a relative movement in a linear direction and a cut groove (10) is formed on the aforementioned long side face by repeated rotation of the aforementioned cutter.

15. A method for the manufacture of a safety mechanism for rectangular batteries characterized in that it has a process in which the rectangular battery is manufactured by housing the electrode plates(13) and electrolytic solution inside a rectangular battery case (1) having a bottom, after which the opening (14) of the aforementioned battery case is sealed, and a process in which a cutter (37) that is installed in a high-speed rotator (30) and that rotates at high speed is brought into contact with the long side face (1a) and cuts into this face in the aforementioned battery case in the aforementioned rectangular battery, after which, while the aforementioned high speed rotator or the aforementioned rectangular battery is subjected to relative movement in a linear direction, a cut groove (40) of a specified shape, the depth of which changes discontinuously is formed in the aforementioned long side face by repeated rotation of the aforementioned cutter, as a result of the relative movement of the aforementioned high speed rotator and the aforementioned battery case in separate directions from one another.

16. A method for the manufacture of a safety mechanism for rectangular batteries as described in claim 14 or 15, further characterized in that, instead of the process in which the cut grooves (10, 40) are formed in the battery case (1) of the aforementioned rectangular battery after manufacturing the rectangular battery, the aforementioned cut grooves are formed in the aforementioned battery case in advance and the electrode plate (13) and the electrolytic solution are housed inside the battery case, after which the opening (14) of the aforementioned battery case is sealed, with the rectangular battery being manufactured.

17. The method for the manufacture of a safety mechanism for rectangular batteries as described in claim 14 in which the high speed rotator (30) in which multiple cutters (37) are installed at specified intervals or the rectangular battery are caused to undergo movement in the linear direction perpendicular to the placement direction of the aforementioned cutters and in which the multiple cut grooves (10, 25) are formed simultaneously in the aforementioned long side face (1a).

図 1



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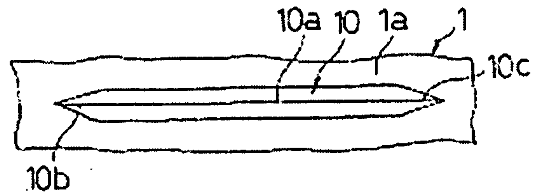

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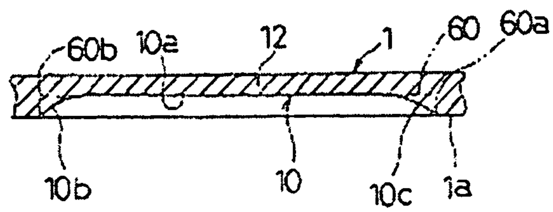

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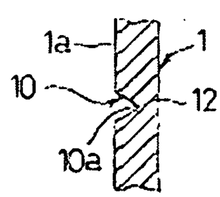

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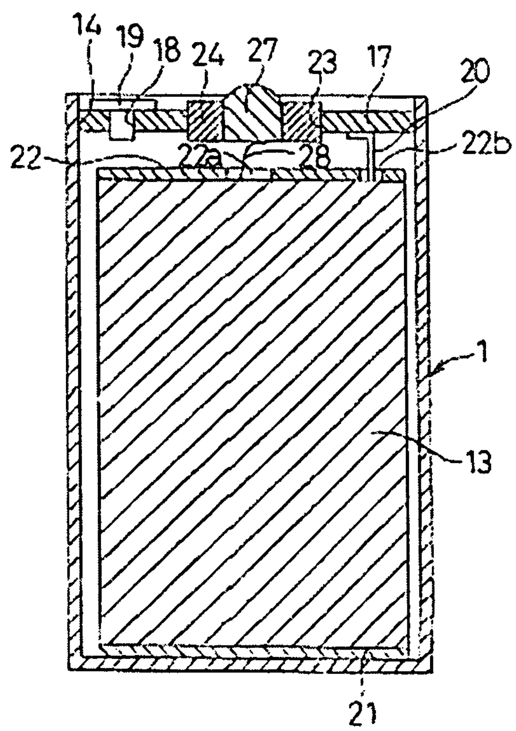

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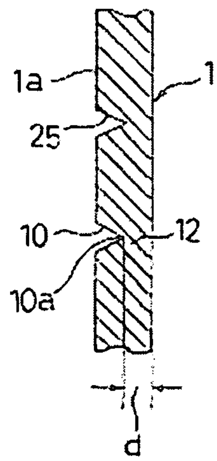

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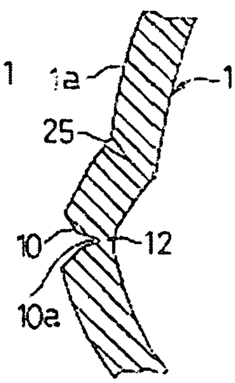

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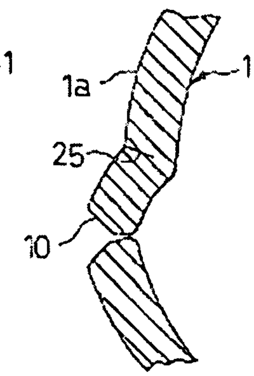

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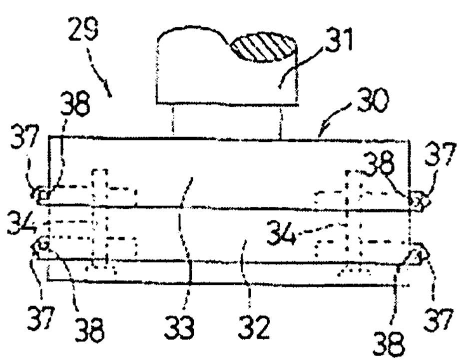

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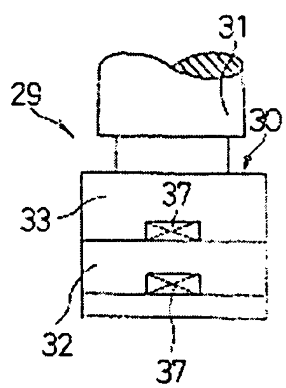

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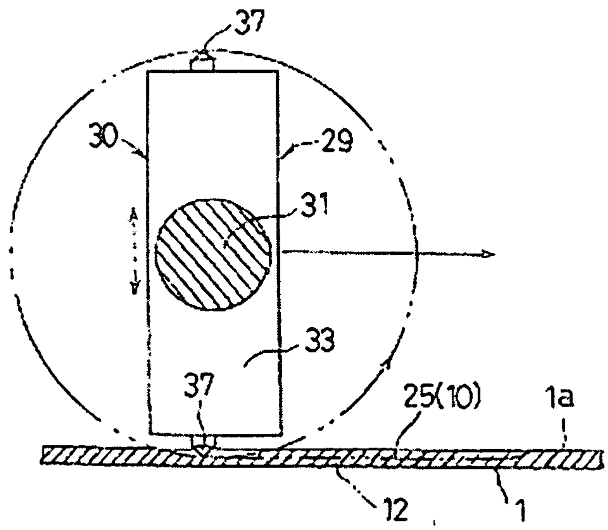

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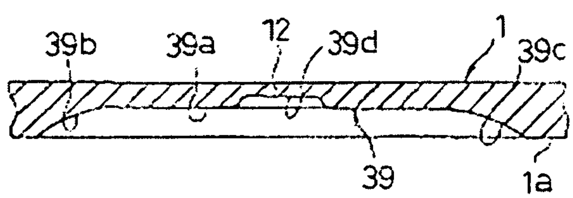

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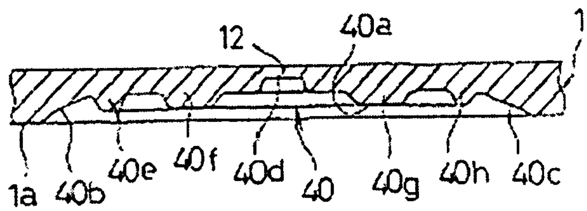

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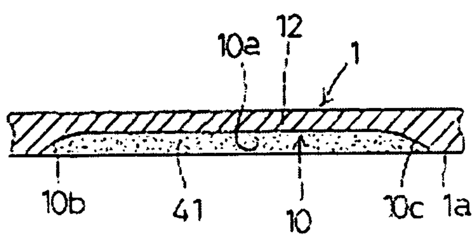

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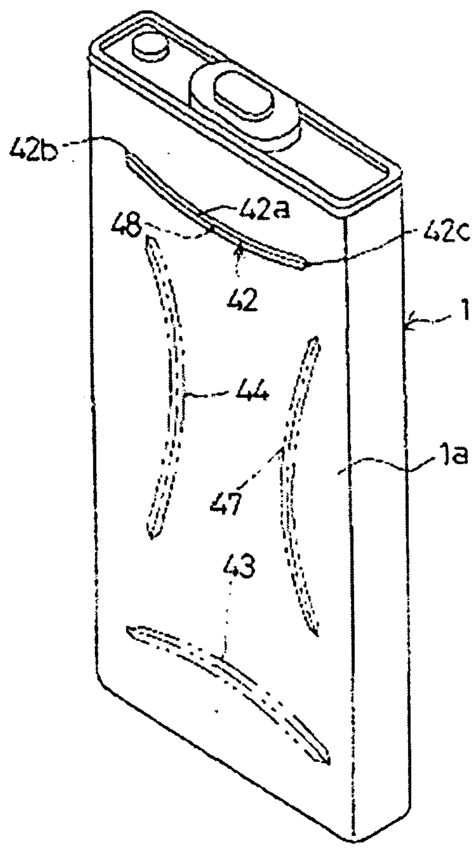

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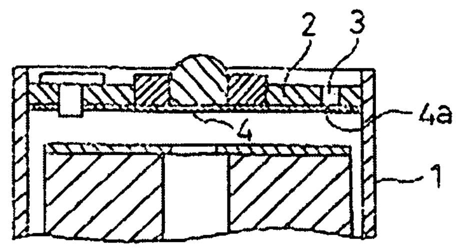

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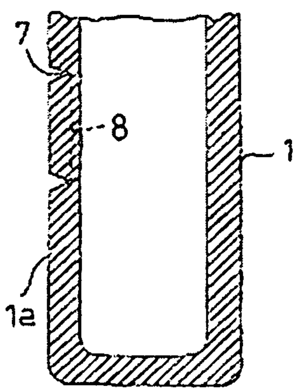

図11C